

New records of snow algae from the Andes of Ecuador

Nuevos registros de algas de los nevados andinos Ecuatorianos

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Abstract

Snow algae are a specialized group of organisms confined to glaciers and snow fields of polar, temperate, and tropical regions. An examination of the surface melt water from the Iliniza glacier (Ecuador) yielded the very first record of the snow alga *Cylindrocystis brebissonii* f. *cryophila* for equatorial regions, and a new record of spherical cysts of the «red snow» alga *Chlamydomonas* cf. *nivalis*, which was previously reported from Pichincha, another Ecuadorian volcano, as various species of the genus *Chlamydomonas*.

Key words: *Chlamydomonas*, cryophilous, *Cylindrocystis*, glacier, Iliniza.

Resumen

Las algas de nieve son un grupo especializado de organismos que se encuentran confinados a los glaciares y campos de nieve de las regiones polares, templadas y tropicales. Un análisis del agua superficial del glaciar Iliniza (Ecuador) produjeron el primer registro del alga de nieve *Cylindrocystis brebissonii* f. *cryophila* para las regiones ecuatoriales, y un nuevo registro para los quistes esféricos del alga de «nieve roja» *Chlamydomonas* cf. *nivalis*, la cuál fue previamente reportada para Pichincha, otro volcán Ecuatoriano, así como varias especies del género *Chlamydomonas*.

Palabras clave: *Chlamydomonas*, cryofilo, *Cylindrocystis*, glaciar, Iliniza.

Introduction

Equatorial glaciers are vanishing at an alarming rate and are predicted to disappear within a few decades (Klein & Kincaid, 2006, P.M. Hall, pers. comm.). The retreat of glaciers affects the ecology and hydrology of tropical mountains in several ways. For instance, on the Iliniza volcano in central Ecuador, the upper páramo belt receives significantly less melt water as the glaciers have retreated during the last decade (pers. comm. from the keepers of the mountain refuge at Iliniza). Soil stability is related to soil water balance (see Podwojewski & Poulenard, 2000). The glacier retreat on Iliniza might be indirectly linked to accelerated soil erosion through altered hydrology, although supporting data is not available. Further, agriculture of many rural communities is largely

dependent on melt water from the glaciers (Kaser et al. 2003, Vincent et al. 2005). Thus declining glaciers will have severe socio-economic consequences.

Along with melting glaciers, a unique type of habitat is disappearing from the tropics, i.e., habitats for cryophilous biota, such as snow algae. Snow algae are a specialized group of extremophiles adapted to harsh conditions; their taxonomy, physiology, and ecology were reviewed by e.g., Kol (1968), Hoham & Duval (2001), and Komárek & Nedbalová (2007). Most results were obtained from the survey of snow fields whereas the knowledge of distribution of the snow algae on glaciers remains limited (Yoshimura et al. 1997; Takeuchi, 2001; Takeuchi & Kohshima, 2004;

Takeuchi et al. 2006). These studies point to the existence of a specific glacier community characterized in particular by green cryosestic algae from the order Zygnematales (*Mesotaenium berggrenii*, *Ancylonema nordenskiöldii* and *Cylindrocystis brebissonii*).

Due to the high degree of isolation from temperate and polar regions the glaciated tropical mountains can be expected to host particular cryofloras. Nevertheless, snow algae research in the tropics has received little attention. The most extensive and most recent study relates to the glaciers of New Guinea (Kol & Peterson, 1976), whereas only very little is known about the snow algae species composition in other tropical alpine regions. In Ecuador, «red snow» was reported from the mountains of Antisana and Pichincha (Lagerheim, 1892). A brief sampling of the perpetual snow fields of Pichincha («ewigen Schnee des Pichincha») yielded 21 species of algae and cyanobacteria, two species of fungi, and one species of rotifer. Since the persistent snow disappeared from Pichincha during the second half of the XIX century (Hastenrath, 1981) the snow algae must be considered extinct on that mountain. Further algological survey of other Ecuadorian glaciers and snow fields was not done, and so the composition of the Ecuadorian cryoflora remains unknown.

In this floristic contribution we report new records for the cryoflora of Ecuador from the glacier of Iliniza. Our results are compared with those from studies of glacier cryovegetation elsewhere.

Study sites and methods

The extensive survey was carried out on three Ecuadorian mountains, Iliniza, Chimborazo, and Cayambe, in October 2006 and August 2007. Iliniza (5126 and 5248 m a.s.l.) is a twin-peak volcano located in the western cordillera. By 1870–74, the snow-line occurred at 4660 m and an individual glacier reached as far down as 4480 m a.s.l. on the western side. The snow-line retreated to ca 4950 m a.s.l. by 1975, and only ca 1.5 km² of the higher of the peaks remained glaciated (Hastenrath 1981). Chimborazo (6310 m a.s.l.) and Cayambe (5790 m a.s.l.) are heavily glaciated complex volcanoes formed by two or more extinct

centers of activity (Sauer, 1971; Hall, 1977). The glaciers retreated on the two mountains during the last centuries to cover the remaining area of 30 km² and 44 km², respectively, by 1975 (Hastenrath, 1981).

The glaciers were surveyed on: 1. the NW side of Iliniza at altitude of 4840 m, 2. W and SE side of Chimborazo at altitudes of 5200 m and 4850 m, respectively, and 3. SW side of Cayambe at altitudes 5200–5500 m. At each study site, several replicate samples of the surface glacier ice and melt water were collected into sterilized plastic vials. The samples were put in a thermos bottle and transported to Quito where they were stored in a refrigerator prior to transportation to the laboratory.

Live samples were examined and photographed in the laboratory using an Olympus BX50 microscope (magnification 1000x) with a DP10 camera system. Confocal microscopy was used to reconstruct the three-dimensional (3D) structure of chloroplasts in the cells of *Cylindrocystis brebissoni* (Leica microscope equipped with AOBs system).

Results

Microscopic examination of the samples revealed a massive occurrence of snow algae in one sample from Iliniza, whereas the remaining samples from Iliniza and any samples from Chimborazo and Cayambe contained no algae. Two species were found in the Iliniza sample, their short description follows.

Cylindrocystis brebissoni (Ralfs) De Bary f. *cryophila* Kol (Chlorophyta, Zygnematales)

Cells cylindrical with rounded apices, 38–50 x 25–30 ¼m (Fig. 1A). Older cells larger, 50–63 x 42–50 ¼m characterized by a progressive accumulation of carotenoids (Fig. 1B). Chloroplast axial with a complicated 3D structure visualized by confocal microscopy (Fig. 2). Dominant species in the sample.

Chlamydomonas cf. *nivalis* (Bauer) Wille (Chlorophyta, Chlamydomonadales)

Red spherical to slightly oval cysts, 25–30 ¼m in diameter, with thick cell wall, usually without mucilage (Fig. 1C). No flagellates were observed. Significantly

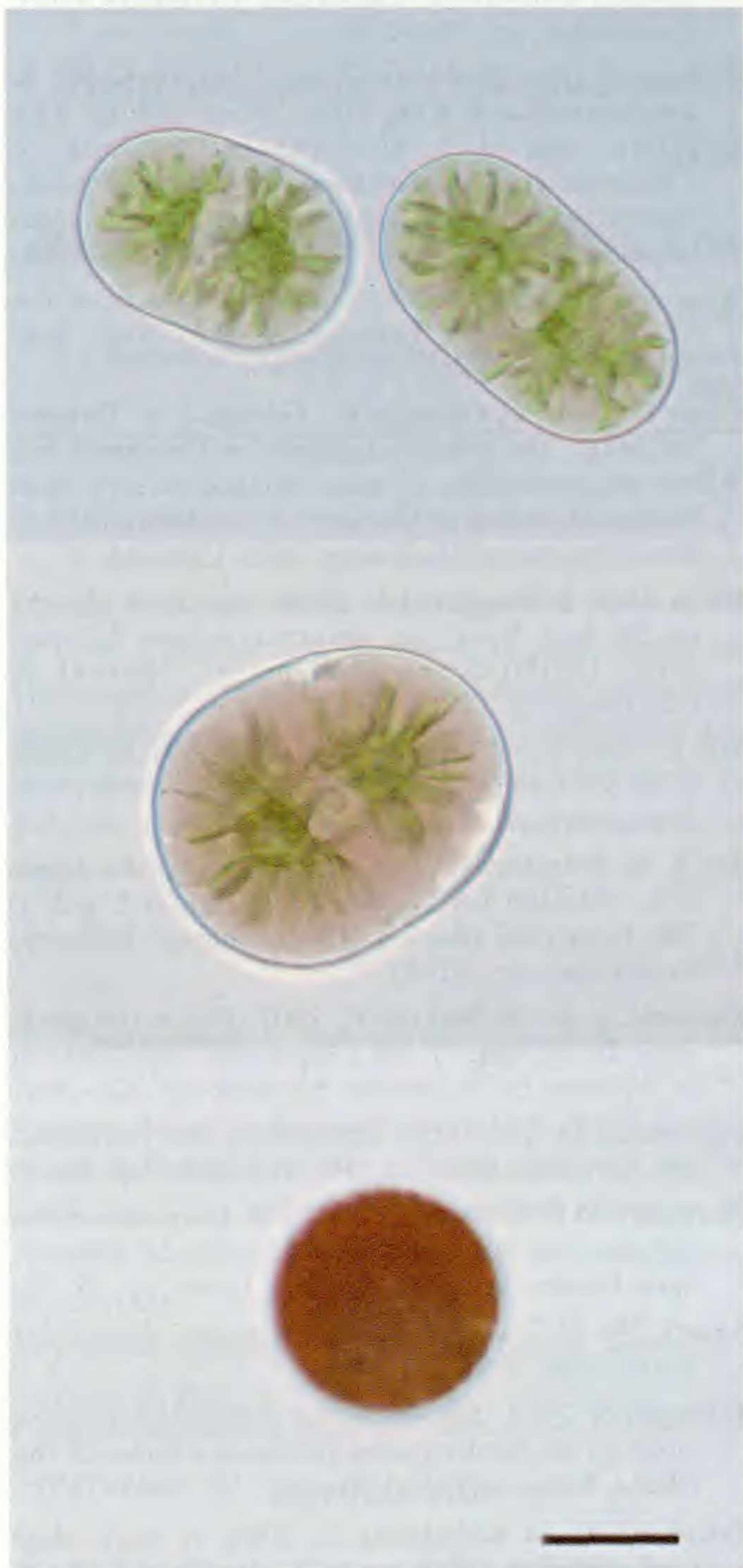


Fig. 1. Snow algae found on the Iliniza glacier (Ecuador). A, B – *Cylindrocystis brebissoni* (Ralfs) De Bary f. *cryophila* Kol, C – *Chlamydomonas* cf. *nivalis* (Bauer) Wille; scale bar = 20 μm

less frequent in the sample in comparison with previous species.

Discussion

Although the cryophilous algae comprise only a minor part of the entire species richness of the Ecuadorian Andes (Jørgensen & León-Y., 1999), they



Fig. 2. 3D chloroplast morphology of *Cylindrocystis brebissoni* cells revealed by confocal microscopy.

represent a very specific plant group that further increases the extraordinary ecological diversity of the tropics. By habitat requirements, cryophilous algae can be divided in two groups, i.e., species inhabiting the snow pack and species confined to glacier ice (Kol, 1968). Both groups were found in Ecuador (Lagerheim, 1892), and their survival in the equatorial Andes is directly related to the future persistence of snow conditions.

Among the two encountered species, *Cylindrocystis brebissoni* f. *cryophila* is considered to be a typical «ice-specialist» which is found in many regions of northern hemisphere, and differ from populations occurring in high bogs by a larger cell size (Kol, 1968). Recently, it was also sampled on the Tyndall glacier in southern Patagonia (Takeuchi & Kohshima, 2004). This study is the first report of the species from equatorial glaciers.

Red resting stages of *Chlamydomonas* were previously reported from Pichincha as three new species of this genus – i.e., *C. sanguinea*, *C. asterosperma*, and *C. glacialis* (Lagerheim, 1892). Only the description of *C. sanguinea* was based on the observation of flagellates. At present, the taxonomy of *Chlamydomonas* species causing the red snow coloration in polar and mountain regions worldwide is rather complicated

and requires detailed study including laboratory cultivation of pure strains and genetic methods (e.g. Hoham et al., 2002). Kol (1968) defined *C. nivalis* as a complex «red snow» species regrouping taxa characterized by a similar morphology of their immotile cells, which are usually the only life cycle stage observed in a sample of red snow. Therefore, we prefer to retain this traditional species name for the *Chlamydomonas* population from the Iliniza glacier. Because of the high degree of geographical isolation, its phenotypical and genotypical comparison with populations originating from polar and temperate regions would be of a particular interest.

Lagerheim (1892) reported «red snow» and observed a rich cryosestic community on Pichincha. In contrast, we did not observe any coloration of the glacier surface which would have indicated blooms of snow algae. Moreover, the microscopic examination of the samples revealed the presence of only two species. Our survey, however, was rather a random sampling than a systematic research of the Ecuadorian cryophilous flora. Overall, the diversity of the cryophilous algae and cyanobacteria in the equatorial regions remains underexplored with only three surveys (including this work) limited to New Guinea and Ecuador. Further study of their distribution, life cycles, and ecological requirements is therefore needed, particularly in the situation of rapidly vanishing snow and ice conditions.

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